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(54) **Valve rotating device for an internal-combustion-engine valve**

(57) The device includes a circular array of rolling bodies (2) disposed in sloping pockets formed in a base member (3). An annular spring disc (1) normally presses the rolling bodies (2) fully down into their pockets. In use of the device, a valve spring so stresses the spring disc (1) during valve opening, as to result in the rolling bodies (2) being relieved of loading by the disc (1); under the urging of springs (8) housed in the pockets, these bodies (2) now move up to the shallower ends of the pockets. As the valve closes, the rolling bodies (2) are loaded again by the disc (1) and the resultant rolling of the bodies (2) down into their pockets causes the base member (3) to rotate relative to the spring disc (1). Further rolling elements (6) are interposed between the spring disc (1) and base member (3), intermediate the rolling bodies (2) and the zone of action (7) of the valve spring on the disc (1).

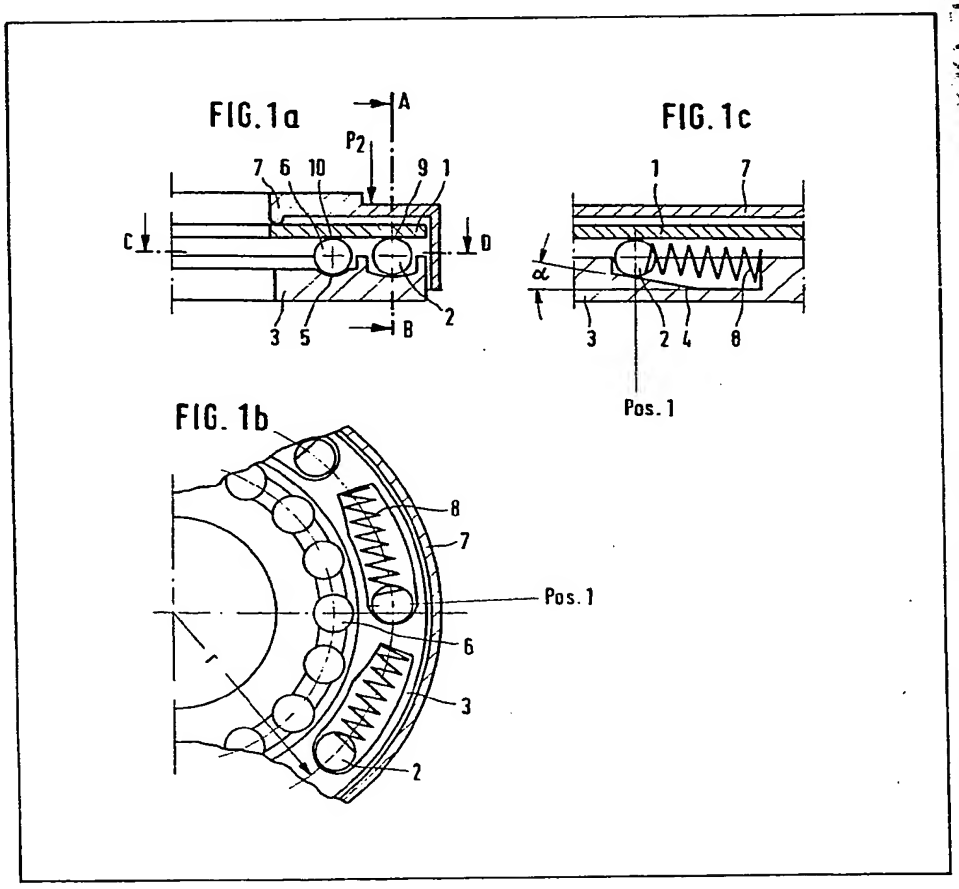

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FIG. 1a

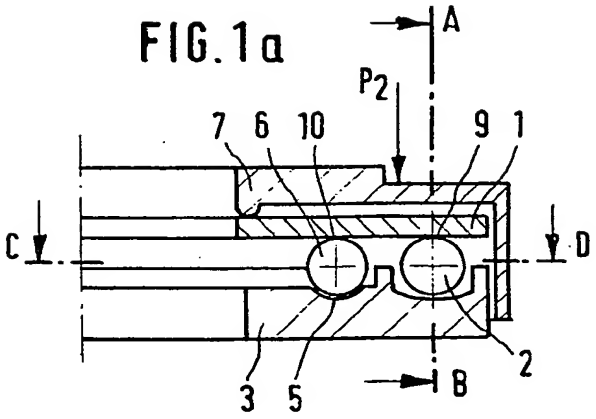


FIG. 1c

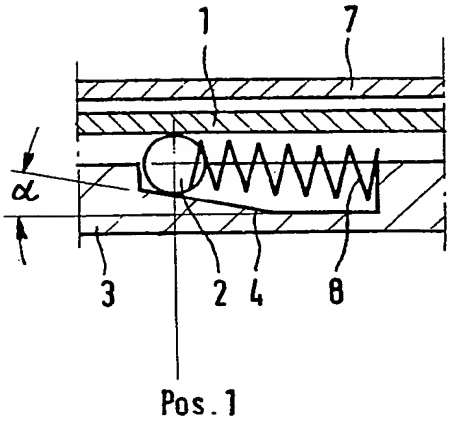


FIG. 1b

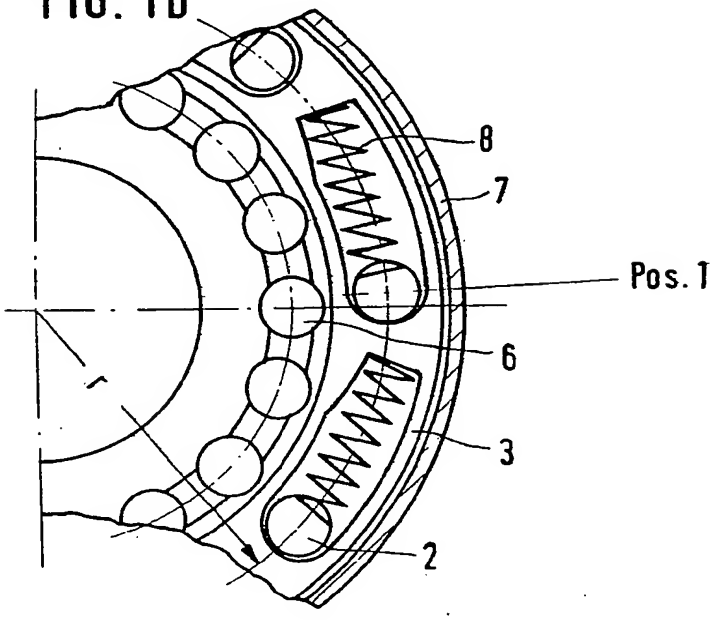


FIG. 2a

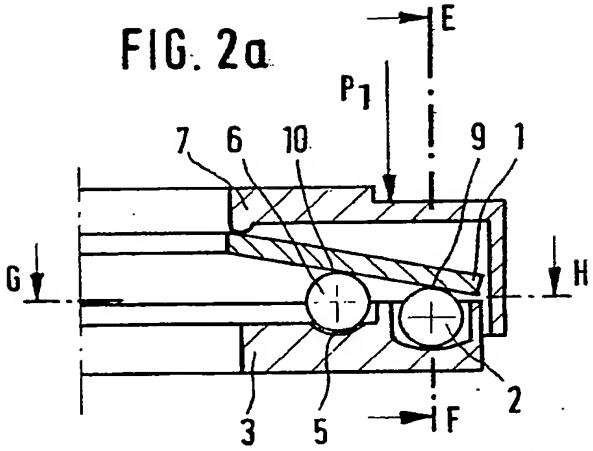


FIG. 2c

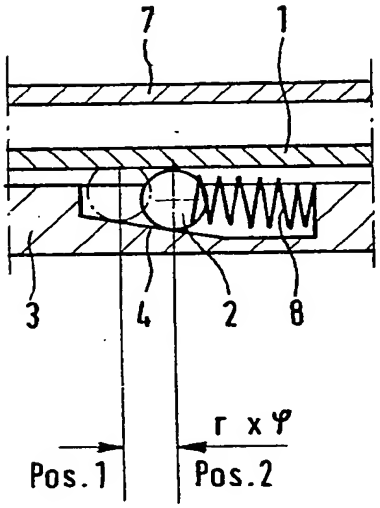


FIG. 2b

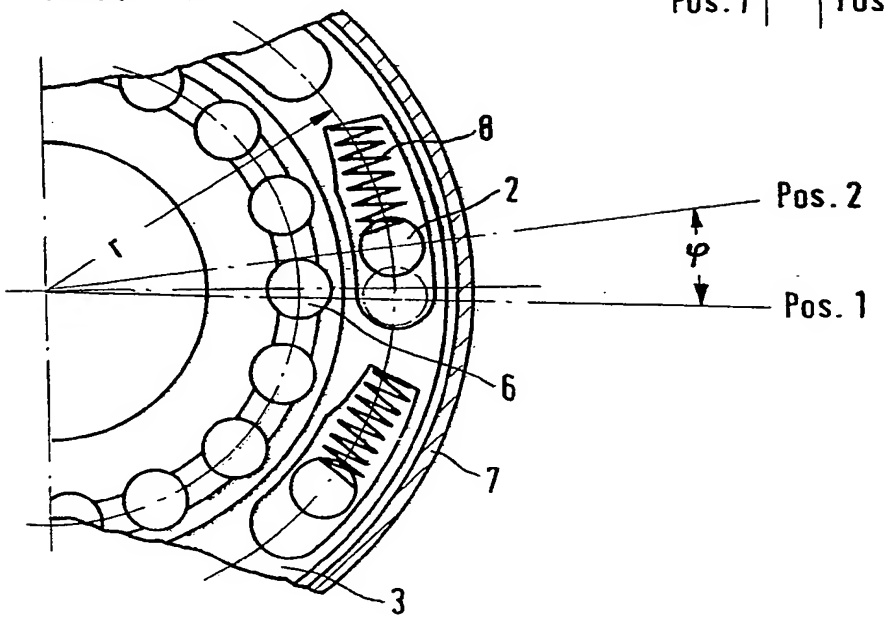


FIG. 3a

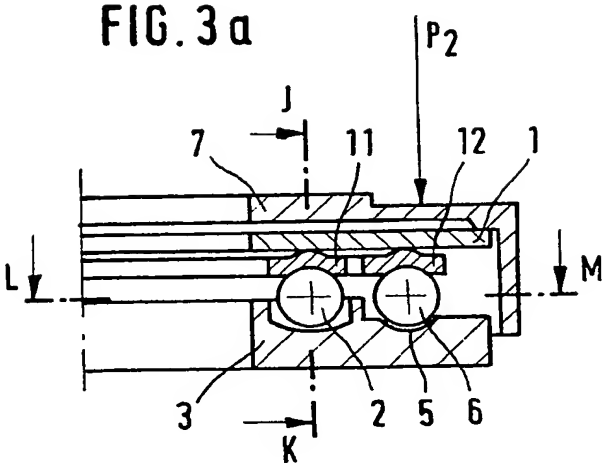


FIG. 3c

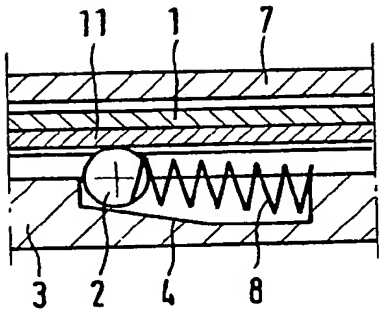
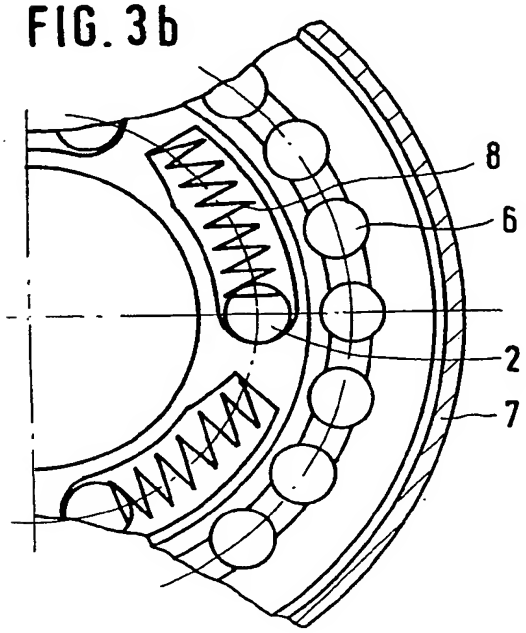


FIG. 3b



SPECIFICATION

Valve rotating device for an internal - combustion - engine valve

The present invention relates to a device for rotating a valve member of an internal combustion engine during translational valve closing movement.

It is known to use valve rotating devices in Otto and Diesel engines provided with valves of the type in which opening movement of a valve member in the valve axial direction is progressively opposed by the force of an axially-acting valve spring. In such cases, the increased force exerted by the valve spring during opening of the valve is used to cause the valve to rotate through a few degrees; during closing of the valve, the device is so arranged that the valve member undergoes no further rotational movement in order to prevent any unnecessary wear on the valve seat. In the case of a Diesel engine fired with heavy oil, however, a rotational movement of the valve member during its closing is desirable in order to remove the glass-like deposits which form; in this case, the valve member should come down on to its seat while still rotating.

Valve rotating devices are known which rotate during the valve closing process, one such valve rotating device being disclosed in German patent specification DE-S 1 955 820. In the device illustrated therein, valve rotation during valve closure is effected using the energy stored in a disc-shaped spring element, in contrast to the devices which effect valve rotation during the opening stroke. The drawback of the device illustrated in this specification is its relatively great constructional bulk both axially and radially in comparison with conventional devices (this being a considerable disadvantage due to the very restricted space available in engines for such devices).

Another valve rotating device effecting rotation during valve closure is disclosed in German patent specification DE-OS 30 04 320. In the device illustrated in this specification, a disc-shaped spring is used as a transmission element for subjecting balls running in inclined pockets to load and for relieving them of load such that the balls, which are held by the spiral springs, move cup springs in such a manner that a rotation of the disc-shaped element is generated (this rotation being used to effect valve rotation). In this case, rotation is effected over the full closing stroke of the valve but, as described on page 18, 2nd paragraph of DE-OS 30 04 320, a rotation also takes place in the opposite direction during the opening, so that the total resulting rotation only has a magnitude equal to the difference between the opening and closing rotations.

The object of the present invention is to provide a valve rotating device which is both compact and causes valve rotation during closing movement, but no abnormal rotation during opening.

According to the present invention, there is provided a device for rotating a valve member of an internal combustion engine during valve closing movement, said device comprising a base member provided with pockets arrayed around an axis of the base member and open in the axial direction thereof, the pockets having circumferentially-extending inclined botton surfaces; rolling bodies disposed in said pockets; springs urging said bodies in the direction of the shallower ends of the pockets; and a spring element disposed opposite the pockets and arranged to load the rolling bodies in said axial direction, the spring element being intended during use of the device to be acted upon, in a predetermined region, by valve spring means such that as the valve opens, the spring element becomes increasingly stressed in said axial direction, the spring element being so arranged that as its axial stressing increases, the loading of the rolling bodies by the spring element is relieved whereas, as the stressing of the spring element decreases, the loading of the rolling bodies increases causing them to roll down into their pockets, against the urging of said springs, and thereby rotate the base member relative to the spring element; the device further comprising additional rolling elements which support the spring element and are disposed on the base member, concentric with the rolling bodies, in the zone between these latter and the said predetermined region in which, during use of the device, the valve spring means loads the spring element.

In contrast to known valve rotating devices, the device of the present invention is thus provided with additional rolling elements for supporting the spring element; in a preferred embodiment, in which the spring element is a flat or conical annular disc, the roller elements support the spring element approximately midway between its inner and outer diameters. These rolling elements are, for example balls, which run in a level, circular groove formed in the base member concentric with its axis. Upon the spring element being axially stressed by the valve spring, the spring element deflects over the circular row of balls. the rolling bodies of the device lie on the inclined bottom surfaces of the pockets, on the opposite side of the rolling elements to the region of application of the valve spring force; these rolling bodies are relieved of load when the spring element is stressed by the valve spring. The slope of the inclined surfaces must be sufficiently large that any resistance to rotation arising from the tangential force derived from the axial force of the valve spring means, by way of the spring element, can be overcome.

Due to its construction, the device of the present invention can be made with a smaller overall size and simpler construction than known valve rotating devices operating on similar principles.

Two forms of valve rotating device, each embodying the present invention, will now be particularly described, by way of example with reference to the accompanying drawings, in which:

Figure 1.1 is a radical section through the first form

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

of the valve rotating device, the device being shown in its state corresponding to the fully open position of an associated valve (not illustrated);

Figure 1.2 is a section on line C-D of Figure 1.1;

Figure 1.3 is a circumferential section on line A-B of Figure 1.1,

Figure 2.1 is a radial section similar to Figure 1.1 but showing the device in its state corresponding to the closed position of the associated valve;

Figure 2.2 is a section on line G-H of Figure 2.1;

Figure 2.3 is a circumferential section on line E-F of Figure 2.1;

Figure 3.1 is a radial section similar to Figure 1.1 but showing the second form of valve rotating device;

Figure 3.2 is a section on line L-M of Figure 3.1; and

Figure 3.3 is a circumferential section on line J-K of Figure 3.1,

The valve rotating devices to be described are intended to effect rotation of a valve member (not shown) during valve closure movement, the valve member being part of an internal - combustion - engine valve which incorporates a valve spring arranged to exert a force P_2 when the valve is open and a lesser force P_1 when the valve is closed.

The first form of valve rotating device (see Figures 1) comprises a spring element in the form of a conical annular disc or cup spring 1, this cup spring 1 being shown stressed into a flat position in Figures 1. The cup spring 1 is supported on rolling bodies 2 and additional rolling elements 6; in the present example, both rolling bodies 2 and rolling elements 6 are constituted by balls. The rolling bodies 2 run in pockets formed in a base member 3, the pockets and thus the bodies 2 being arranged in a circular array of radius *r* about an axis *a-b* of the base member 3. The bottoms of the pockets provide circumferentially - extending roller paths 4 inclined at an angle α to the plane of the stressed cup spring 1. As will become clear hereinafter, during valve closure movement the rolling bodies 2, under the urging of the cup spring 1, roll down these paths 4 into the pockets. Compression springs 8 ensure that the rolling bodies 2, when not loaded by the cup spring 1, are pushed up the paths 4 into the shallower ends of the pockets. A cover 7 placed on the cup spring 1 has an inner lip which engages the inner edge region of the spring 1. The cover 7 serves to transmit the force exerted by a valve spring (not shown) to the said region of the cup spring; in Figures 1 in which the device is shown in its state corresponding to the associated valve being open, the valve spring force is P_2.

The rolling elements 6 are disposed on the base member 3 in an arrangement concentric with that of the rolling bodies 2 such that the elements 6 lie between the bodies 2 and the region of application of the valve spring force to the cup spring 1. In the form of the device illustrated in Figures 1 and 2, the elements 6 are positioned radially inwards of the rolling body running circle; however, in the figure 3 device where the cover 7 is so formed that the valve spring force acts on the radially outer edge of the cup spring 1, the elements 6 are positioned radially outwards of the rolling-body running circle.

The rolling elements 6 form support points 10, so that the cup spring 1 acts as a double-arm lever. The points of contact of the rolling bodies 2 with the cup spring 1 is indicated by 9.

In order to reduce the pressure per unit of area on the base member 3, the rolling elements 6 move in a running groove 5. The roller paths 4 of the pockets housing the rolling bodies 2 are also provided with a curvature in order to reduce the pressure unit of area exerted by the bodies 2 on the base member 3.

The contact points 9 and 10 of the balls 2 and of the balls 6 with the cup spring 1 can likewise be defined advantageously by means of ball raceways, in order to attain good guiding of the cup spring 1 and a reduction in the rolling pressure between the balls 2 and the cup spring 1 and between the row of balls 6 and the cup spring 1.

As already mentioned, Figure 1 shows the valve rotating device in its state corresponding to the associated valve being fully open. The large force P_2 exerted by the valve spring axially stresses the cup spring 1 into a flat state; as a result, the rolling bodies 2 are substantially unloaded by the spring 1 and have thus been moved up to the shallower ends of their pockets by the springs 8. When the valve is open, the axially-stressed cup spring 1 is thus primarily supported on the rolling elements 6, though the balls 2 also make contact with the cup spring 1. The balls 2 are also in contact, of course, with the roller paths.

As the axial force P_2 applied by the valve spring is reduced during closing the valve, ulitmately to the value P_1, the stressed cup spring 1 progressively returns to its conical form and, as a result exerts forces on the balls 2. These balls 2 will, as a consequence of the circumferential force components experienced thereby, now roll down their roller paths 4 into their pockets. The rolling movement of the balls 2 is transmitted to the cup spring 1, which as a result, is displaced through a distance equal to double the rolling distance of the balls 2, and thus together with the cover 7 rotates about the axis A-B of the base member.

Figure 2 show the device at the end of rotation. The balls 2 are located at the greatest depth which they attain in rolling down the roller paths 4, these balls having rolled from position 1 indicated Figures 1.2 and 1.3, to position 2 indicated in Figures 2.2 and 2.3. More particularly, the balls 2 have undergone translation through an angle φ (Figure 2.2) and rolled a distance of $r\varphi$, (Figure 2.3) so that the cup spring 1 has been rotated through $2.\varphi$, and rolled through a distance of $2\ r.\varphi$.

Figure 3 shows the second form of valve rotating device, this device being similar to that shown in Figure 1 but with the balls 2 now being disposed at the inner edge of the base member 3. The row of balls 6 is again located approximately in the middle of the solid cross-sectional part of the base member 3 and of the cup spring 1. The cover 7 is so designed as to apply the valve spring force to the outer edge of the cup spring 1. Two ball race rings 11 and 12 are provided to further ease the rolling pressure from the cup spring 1, this pressure being exerted on this latter by the balls 2 and the row of balls 6. The opera-

tion of the embodiment shown in Figure 3 is the same as that shown in Figure 1. At the end of rotation, the representation of the second form of device would be analogous to Figure 2, but with the inclination of the cup spring reversed.

With both the embodiments of Figures 1 and 3, the rolling elements represented as the row of balls 6 can be advantageously replaced by a complete axial antifriction bearing of known construction, e.g. an axial ball bearing, an axial roller bearing or an axial needle bearing. In addition, both embodiments of the valve rotating device can be a arranged in known manner for fixing the valve rotating device to the end of the stem of the valve to be rotated, for example by providing an inside taper in the base member 3 for receiving valve tapered pieces. Furthermore, although the circumferentially - extending roller paths 4 preferably have the arcuate plan form illustrated in Figure 1.3, the term "circumferentially - extending" is intended to include any plan form of path 4 having a substantial, inclined, component extending about the axis *a-b*.

CLAIMS

1. A device for rotating a valve member of an internal combustion engine during valve closing movement, said device comprising a base member provided with pockets arrayed around an axis of the base member and open in the axial direction thereof, the pockets having circumferentially - extending inclined bottom surfaces; rolling bodies disposed in said pockets; springs urging said bodies in the direction of the shallower ends of the pockets; and a spring element disposed opposite the pockets and arranged to load the rolling bodies in said axial direction, the spring element being intended during use of the device to be acted upon, in a predetermined region, by valve spring means such that as the valve opens, the spring element becomes increasingly stressed in said axial direction, the spring element being so arranged that as its axial stressing increases, the loading of the rolling bodies by the spring element is relieved whereas, as the stressing of the spring element decreases, the loading of the rolling bodies increases causing them to roll down into their pockets, against the urging of said springs, and thereby rotate the base member relative to the spring element; the device further comprising additional rolling elements which support the spring element and are disposed on the base member, concentric with the rolling bodies, in the zone between these latter and the said predetermined region in which, during use of the device, the valve spring means loads the spring element.

2. A device as claimed in Claim 1, wherein the spring element is in the form of a conical annular disc.

3. A device as claimed in Claim 1, wherein the spring element is in the form of a flat annular disc.

4. A device as claimed in any one of Claims 1 to 3, wherein the spring element is formed with recessed roller paths for guiding the rolling bodies and the rolling elements.

5. A device as claimed in any one of Claims 1 to 3, wherein a rolling-body race ring is disposed between the spring element and the rolling bodies.

6. A device as claimed in any one of Claims 1 to 3 and 5, wherein a rolling-element race ring is disposed between the spring element and the rolling elements.

7. A device as claimed in any one of Claims 1 to 6, wherein the rolling elements are incorporated into an axial antifriction bearing.

8. A device as claimed in any one of Claims 1 to 7, wherein the base member comprises a central opening the surface of which is provided with an inside taper for receiving tapered pieces in order to fix the device to the end of the valve member to be rotated.

9. A valve rotating device substantially as hereinbefore described with reference to Figures 1 and 2 or Figure 3 of the accompanying drawings.

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